



US010693214B2

(12) **United States Patent**  
**Kim et al.**

(10) **Patent No.:** **US 10,693,214 B2**

(45) **Date of Patent:** **\*Jun. 23, 2020**

(54) **MOBILE TERMINAL**

(71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)

(72) Inventors: **Dongjin Kim**, Seoul (KR); **Yunmo Kang**, Seoul (KR); **Youngbae Kwon**, Seoul (KR); **Yeomin Youn**, Seoul (KR); **Jihun Ha**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.  
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/530,760**

(22) Filed: **Aug. 2, 2019**

(65) **Prior Publication Data**

US 2019/0356040 A1 Nov. 21, 2019

**Related U.S. Application Data**

(63) Continuation of application No. 16/020,925, filed on Jun. 27, 2018, now Pat. No. 10,431,872.  
(Continued)

(30) **Foreign Application Priority Data**

May 3, 2018 (KR) ..... 10-2018-0051313

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 13/10** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/242** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... H01Q 1/242; H01Q 21/30; H01Q 13/10; H04B 1/401

(Continued)

(56) **References Cited**

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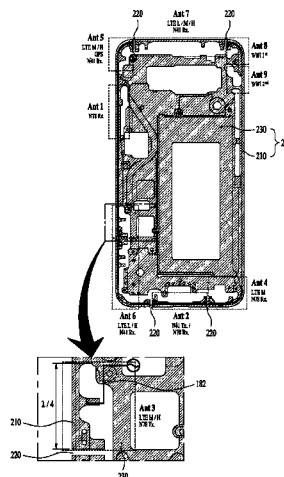
*Primary Examiner* — Ayodeji O Ayotunde

(74) *Attorney, Agent, or Firm* — Lee, Hong Degerman, Kang & Waimey

(57) **ABSTRACT**

A mobile terminal is provided including a display unit; a middle frame including a supporting unit that supports a rear surface of the display unit with a side portion around the supporting portion; a main board at a rear surface of the middle frame including a ground; a first wireless communication unit in the main board to transceive a first signal; a second wireless communication unit in the main board to transceive a second signal; and a rear case covering a rear surface of the main board, where the side portion includes a plurality of conductive members with ends divided into slits and the plurality of the conductive members includes a common antenna electrically connectable with the first and second wireless communication units to receive the first and second signals such that the mobile terminal receives dif-

(Continued)





(12) **United States Patent**  
**Park et al.**

(10) **Patent No.:** **US 10,693,215 B2**  
(45) **Date of Patent:** **Jun. 23, 2020**

(54) **ANTENNA ASSISTANT DEVICE AND ELECTRONIC DEVICE INCLUDING THE SAME**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si, Gyeonggi-do (KR)

(72) Inventors: **Jung Sik Park**, Suwon-si (KR); **Seung Gil Jeon**, Suwon-si (KR); **Jung Su Ha**, Osan-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si, Gyeonggi-do (KR)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 236 days.

(21) Appl. No.: **15/411,075**

(22) Filed: **Jan. 20, 2017**

(65) **Prior Publication Data**  
US 2017/0214123 A1 Jul. 27, 2017

(30) **Foreign Application Priority Data**  
Jan. 27, 2016 (KR) ..... 10-2016-0009848

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01P 1/203** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01P 1/20345** (2013.01); **H01Q 1/38** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/335; H05K 1/162; H05K 1/165; H03H 7/0115; H03H 2001/0078; H01F 17/00-17/0013; H01G 4/30  
See application file for complete search history.

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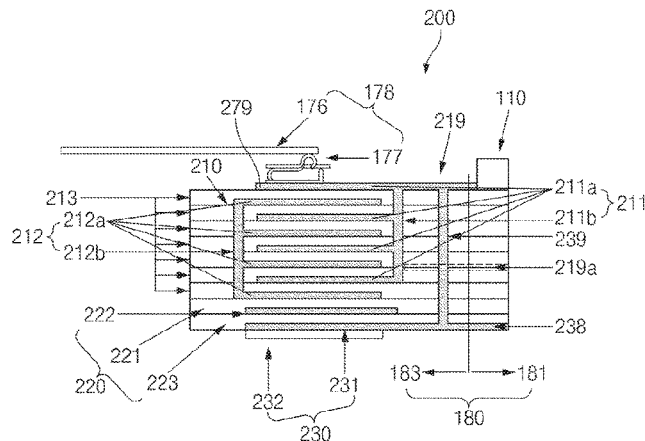
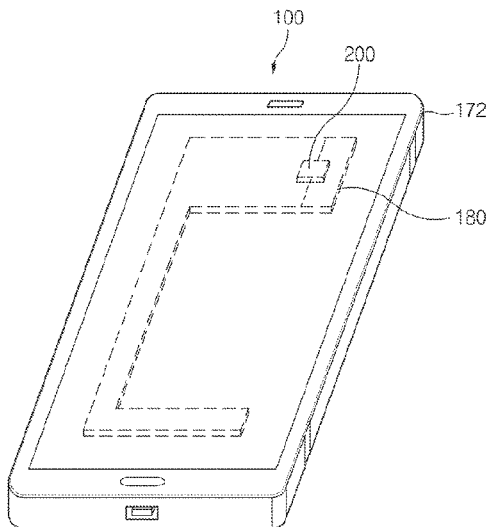
Search Report and Written Opinion dated May 4, 2017 in counterpart International Patent Application No. PCT/KR2017/000615.  
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*Primary Examiner* — Ricardo I Magallanes  
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing, a communication circuit disposed on one side of the housing, a multi-layered printed circuit board (PCB) disposed on one side of the housing and electrically connected to the communication circuit and an antenna radiator disposed on one side of the housing or defining at least a portion of an outer surface of the housing, and is electrically connected to the communication circuit and the multi-layered printed circuit board, wherein the multi-layered printed circuit board comprises a first conductive pattern disposed in at least one of a plurality of layers thereof to form a capacitance, a second conductive pattern disposed in at least another one of the plurality of layers thereof to form an inductance and a conductive plate disposed between the at least one and the at least other one of the plurality of layers and is electrically isolated from the first conductive pattern and the second conductive pattern.

**14 Claims, 31 Drawing Sheets**





US010693216B1

(12) **United States Patent**  
**Ryu et al.**

(10) **Patent No.:** **US 10,693,216 B1**

(45) **Date of Patent:** **\*Jun. 23, 2020**

(54) **MOBILE TERMINAL HAVING AN ANTENNA INCLUDING DIELECTRICS ON A CIRCUIT BOARD**

(2013.01); **H01Q 21/20** (2013.01); **H04M 1/02** (2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 5/30; H01Q 1/24; H01Q 1/38; H01Q 21/20; H01Q 3/26; H01Q 21/205; H01Q 9/0435; H01Q 3/2623; H04M 1/026; H04M 1/02; H04M 1/0202

See application file for complete search history.

(71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)

(72) Inventors: **Seungwoo Ryu**, Seoul (KR); **Joohee Lee**, Seoul (KR); **Wonwoo Lee**, Seoul (KR); **Junyoung Jung**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/797,506**

(22) Filed: **Feb. 21, 2020**

**Related U.S. Application Data**

(63) Continuation of application No. 16/345,899, filed as application No. PCT/KR2016/012449 on Nov. 1, 2016, now Pat. No. 10,637,127.

*Primary Examiner* — Brandon J Miller

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H04M 1/02** (2006.01)  
**H01Q 5/30** (2015.01)  
**H01Q 3/26** (2006.01)  
**H01Q 21/20** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 1/38** (2006.01)

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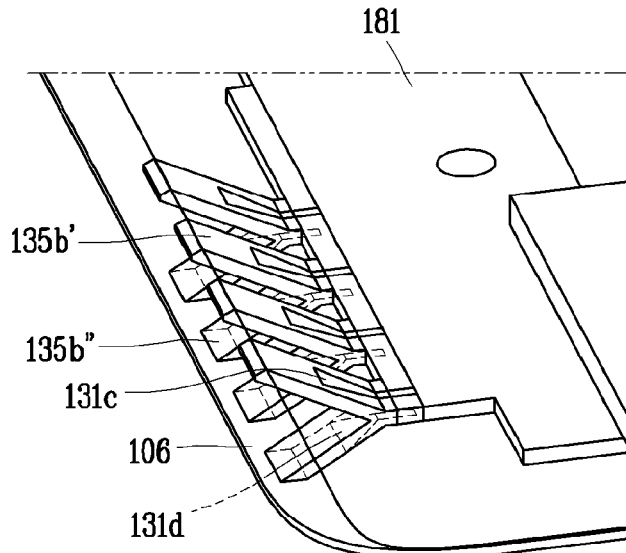
**ABSTRACT**

A mobile terminal includes a terminal body and an antenna device configured to generate a resonant frequency of a frequency band for 5G communication system. Further, the antenna device is an antenna array including a plurality of dielectrics operating as a resonator. The mobile terminal also includes a circuit board including a feeding unit and a ground plane and configured to be inserted into each of the dielectrics such that a portion of the circuit board protrudes outward.

(52) **U.S. Cl.**

CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 3/26** (2013.01); **H01Q 5/30** (2015.01); **H01Q 9/04**

**13 Claims, 17 Drawing Sheets**



(12) **United States Patent**  
**Kim et al.**

(10) **Patent No.:** **US 10,693,506 B2**  
(45) **Date of Patent:** **Jun. 23, 2020**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Suwon-si, Gyeonggi-do (KR)

(72) Inventors: **Young Ju Kim**, Suwon-si (KR); **Jong Hyuk Kim**, Yongin-si (KR); **Sung Chul Park**, Seoul (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/777,026**

(22) PCT Filed: **Nov. 16, 2016**

(86) PCT No.: **PCT/KR2016/013167**

§ 371 (c)(1),  
(2) Date: **May 17, 2018**

(87) PCT Pub. No.: **WO2017/099383**

PCT Pub. Date: **Jun. 15, 2017**

(65) **Prior Publication Data**

US 2018/0337697 A1 Nov. 22, 2018

(30) **Foreign Application Priority Data**

Dec. 10, 2015 (KR) ..... 10-2015-0176037

(51) **Int. Cl.**  
**H04B 17/19** (2015.01)  
**H04B 17/24** (2015.01)

(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04B 1/0064** (2013.01); **G01R 29/08** (2013.01); **G01R 29/10** (2013.01); **H01Q 1/24** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC .... H04B 1/0064; H04B 17/16; H04B 7/0602; H04B 17/19; H04B 17/14; H04B 17/21;  
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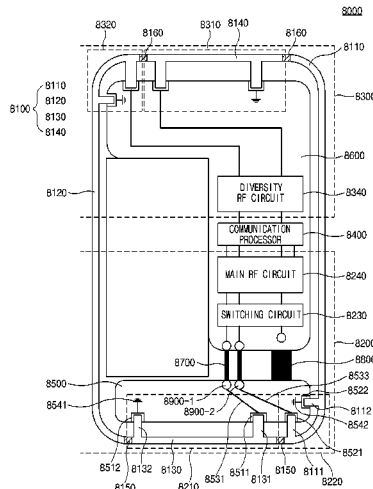
(Continued)

*Primary Examiner* — Pablo N Tran

(57) **ABSTRACT**

An electronic device includes a housing, a communication circuit positioned inside the housing, and including a first port for a first frequency band and a second port for a second frequency band, a first antenna positioned inside the housing or forming a part of the housing, a second antenna positioned inside the housing or forming a part of the housing, a test port positioned inside the housing or at least partially exposed through the housing, and a switching circuit configured to selectively connect one or more of the first port or the second port to one or more of the first antenna, the second antenna, or the test port.

**19 Claims, 14 Drawing Sheets**



(12) **United States Patent**  
**Han et al.**

(10) **Patent No.:** **US 10,693,516 B2**  
(45) **Date of Patent:** **Jun. 23, 2020**

(54) **ELECTRONIC DEVICE HAVING  
ADJUSTABLE ANTENNA SETTINGS**

USPC ..... 455/77  
See application file for complete search history.

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Liang Han**, Sunnyvale, CA (US);  
**Matthew A. Mow**, Los Altos, CA (US);  
**Mattia Pascolini**, San Francisco, CA  
(US); **Ruben Caballero**, San Jose, CA  
(US); **Thomas E. Biedka**, San Jose,  
CA (US); **Yuancheng Xu**, Melbourne,  
FL (US); **Iyappan Ramachandran**,  
Santa Clara, CA (US)

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(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(\* ) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **16/017,847**

(22) Filed: **Jun. 25, 2018**

*Primary Examiner* — Eugene Yun

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;  
Michael H. Lyons; Tianyi He

(65) **Prior Publication Data**

US 2019/0393918 A1 Dec. 26, 2019

(57) **ABSTRACT**

(51) **Int. Cl.**

**H04B 1/3827** (2015.01)  
**H04M 1/03** (2006.01)  
**H04M 1/02** (2006.01)  
**G06K 9/20** (2006.01)  
**H04M 1/725** (2006.01)

(Continued)

An electronic device may include control circuitry, sensors, and wireless circuitry having antennas. The sensors may generate sensor data that is used by the control circuitry to identify an operating environment for the device. The sensor data may include a grip map generated by a touch-sensitive display, infrared facial recognition image signals or other image signals, an angle of arrival of sound received by a set of microphones, impedance data from an impedance sensor, and any other desired sensor data. The control circuitry may use the sensor data, radio-frequency spatial ranging data, information about whether audio is being played over an ear speaker, and/or information about communications protocols in use to identify the operating environment. The control circuitry may adjust antenna settings for the wireless circuitry based on the identified operating environment to ensure that the antennas operate with satisfactory antenna efficiency regardless of operating conditions.

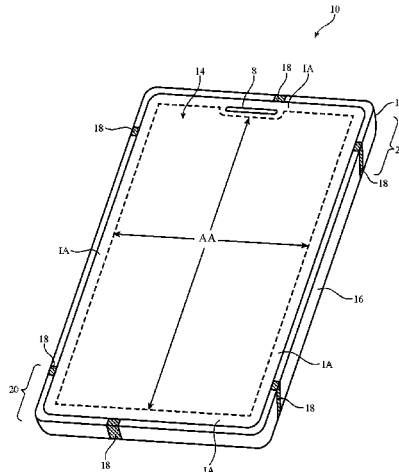
(52) **U.S. Cl.**

CPC ..... **H04B 1/3838** (2013.01); **G06K 9/2018**  
(2013.01); **G06K 9/6289** (2013.01); **G06T**  
**7/521** (2017.01); **G06T 7/55** (2017.01); **H04M**  
**1/0264** (2013.01); **H04M 1/03** (2013.01);  
**H04M 1/72569** (2013.01); **H04W 52/283**  
(2013.01)

(58) **Field of Classification Search**

CPC ..... H04B 1/3838; G06T 7/55; G06T 7/521;  
H04M 1/0264; H04M 1/03; H04M  
1/72569; H04W 52/283; G06K 9/6289;  
G06K 9/0218

**20 Claims, 13 Drawing Sheets**



(12) **United States Patent**  
**Huang et al.**

(10) **Patent No.:** **US 10,700,409 B2**  
(45) **Date of Patent:** **Jun. 30, 2020**

(54) **BACK COVER FOR ELECTRONIC DEVICE AND ELECTRONIC DEVICE**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventors: **Shih-Ting Huang**, New Taipei (TW);  
**Ching-Chi Lin**, New Taipei (TW);  
**Chien-Wen Chen**, New Taipei (TW);  
**Chuan-Chun Wang**, New Taipei (TW)

(73) Assignee: **Acer Incorporated**, New Taipei (TW)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 37 days.

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(22) Filed: **Dec. 17, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 27, 2018 (TW) ..... 107134186 A

(51) **Int. Cl.**  
**H01Q 1/22** (2006.01)  
**H01Q 1/24** (2006.01)  
**G06F 1/16** (2006.01)  
**H01Q 5/30** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/2266** (2013.01); **G06F 1/1698**  
(2013.01); **H01Q 1/24** (2013.01); **H01Q 5/30**  
(2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/22; H01Q 1/2258; H01Q 1/2266;  
H01Q 1/24; H01Q 1/241; H01Q 1/243;  
H01Q 5/30; H01Q 5/335  
See application file for complete search history.

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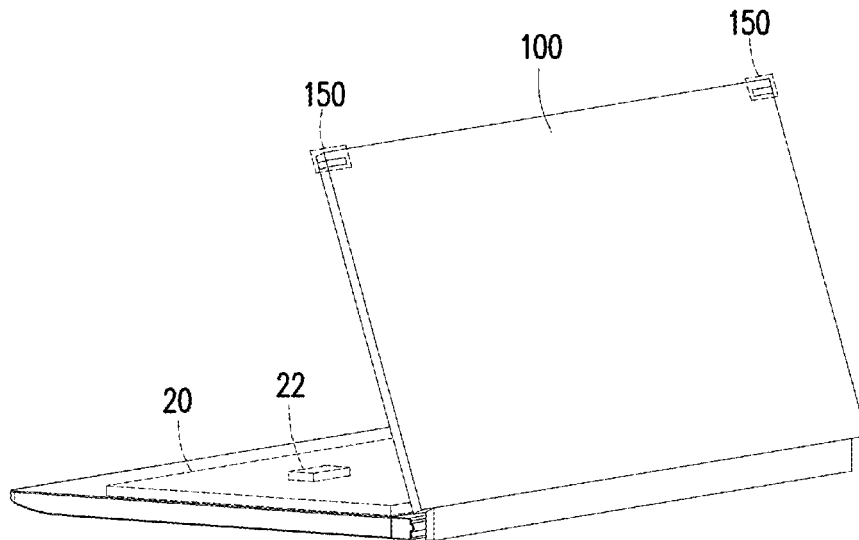
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A back cover includes a metal body having a first side, a second side, and a groove that is formed at the first side. The metal body further has a first radiator, a second radiator, and a ground radiator. The first radiator is disposed in the groove, and has a main portion and a support portion that cooperatively form a T-shape. The main portion includes a feeding end adjacent to a closed end of the groove. The second radiator is adjacently connected to the groove and is defined by the first and second sides, and an edge of the groove. The ground radiator is formed by a portion of the metal body excluding the first and second radiators. The second radiator and the support portion are connected to the ground radiator. The first and second radiators, and the ground radiator serve as an antenna structure.

**17 Claims, 5 Drawing Sheets**





(12) **United States Patent**  
**Shin et al.**

(10) **Patent No.:** **US 10,700,415 B2**  
(45) **Date of Patent:** **Jun. 30, 2020**

(54) **ANTENNA OF ELECTRONIC DEVICE INCLUDING DISPLAY**

(71) Applicant: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR)

(72) Inventors: **Dong Ryul Shin**, Daegu (KR); **Young Gwon Koo**, Seoul (KR); **Ho Saeng Kim**, Gyeonggi-do (KR); **Jin Woo Jung**, Seoul (KR); **Jae Bong Chun**, Gyeonggi-do (KR); **Hyun Suk Choi**, Daegu (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 360 days.

(21) Appl. No.: **15/443,822**

(22) Filed: **Feb. 27, 2017**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Feb. 26, 2016 (KR) ..... 10-2016-0023548

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H04M 1/02** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **G06F 1/1626** (2013.01); **G06F 1/1637** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 13/10; H01Q 21/28; H01Q 1/52  
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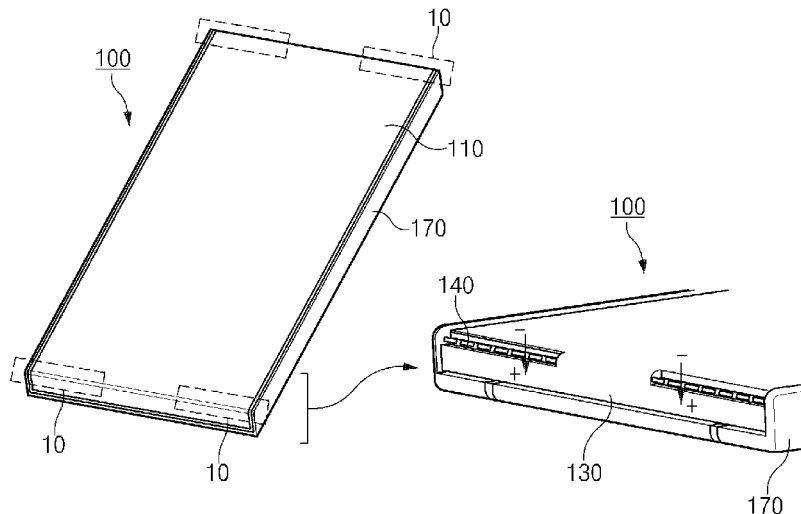
*Primary Examiner* — Huedung X Mancuso

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device is provided, which includes a housing including a first plate, a second plate, and a side plate surrounding part of a space between the first plate and the second plate, a display positioned inside the housing and exposed through the first plate, a first conductive plate attached to or integrated into the display, wherein the first conductive plate faces the first direction and includes a first periphery extending along the side plate, a second conductive plate facing the third direction, wherein the second conductive plate includes a second periphery extending along the first periphery and a portion of the second periphery is coupled to the first periphery, and a wireless communication circuit electrically connected to the second conductive plate and configured to use at least one of the first conductive plate or the second conductive plate as an antenna element.

**20 Claims, 17 Drawing Sheets**





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(12) **United States Patent**  
**Kwon et al.**

(10) **Patent No.:** **US 10,700,417 B1**  
(45) **Date of Patent:** **Jun. 30, 2020**

(54) **MOBILE TERMINAL**

(56) **References Cited**

(71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)

U.S. PATENT DOCUMENTS

(72) Inventors: **Youngbae Kwon**, Seoul (KR); **Gihwan Kim**, Seoul (KR); **Dongjin Kim**, Seoul (KR)

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				343/853
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(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **16/815,978**

\* cited by examiner

(22) Filed: **Mar. 11, 2020**

**Related U.S. Application Data**

*Primary Examiner* — Nhan T Le

(63) Continuation of application No. PCT/KR2018/005112, filed on May 2, 2018.

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(60) Provisional application No. 62/655,212, filed on Apr. 9, 2018.

(57) **ABSTRACT**

(51) **Int. Cl.**

<b>H04M 1/00</b>	(2006.01)
<b>H01Q 1/24</b>	(2006.01)
<b>H01Q 5/307</b>	(2015.01)
<b>H01Q 21/06</b>	(2006.01)
<b>H04M 1/02</b>	(2006.01)

A mobile terminal includes a terminal main body including a circuit substrate configured to process first and second wireless signals; a sidewall portion including slits and an antenna member exposed outside of the main body so as to make up an appearance of the main body, wherein the antenna member is formed between the slits and includes multiple antenna slots; a first power supply unit extending from the circuit substrate and configured to supply power to the antenna member so the first wireless signal is transmitted and received through the antenna member; and a second power supply unit configured to supply power to the multiple antenna slots such that the second wireless signal is transmitted and received through the multiple antenna slots in a different frequency band than the first wireless signal.

(52) **U.S. Cl.**

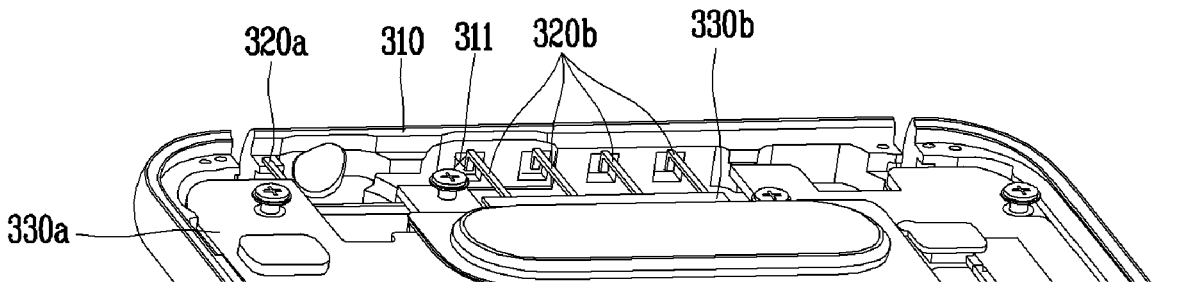
CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/307** (2015.01); **H01Q 21/064** (2013.01); **H04M 1/0262** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 21/06; H01Q 21/22; H01Q 5/307; H01Q 21/065; H04W 52/0261; H04M 1/0202

See application file for complete search history.

**17 Claims, 13 Drawing Sheets**





(12) **United States Patent**  
**Li**

(10) **Patent No.:** **US 10,700,425 B2**  
(45) **Date of Patent:** **Jun. 30, 2020**

(54) **MULTI-FEED ANTENNA**

(71) Applicants: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (TW)

(72) Inventor: **Chih-Cheng Li**, Taipei (TW)

(73) Assignees: **INVENTEC (PUDONG) TECHNOLOGY CORPORATION**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (TW)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/214,350**

(22) Filed: **Dec. 10, 2018**

(65) **Prior Publication Data**  
US 2020/0168988 A1 May 28, 2020

(30) **Foreign Application Priority Data**  
Nov. 28, 2018 (CN) ..... 2018 1 1433065

(51) **Int. Cl.**  
**H01Q 1/52** (2006.01)  
**H01Q 5/35** (2015.01)  
**H01Q 7/00** (2006.01)  
**H01Q 9/30** (2006.01)  
**H01Q 1/24** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/521** (2013.01); **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/30** (2013.01); **H01Q 5/35** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/521; H01Q 1/243; H01Q 7/00; H01Q 9/30; H01Q 5/35  
See application file for complete search history.

(56) **References Cited**

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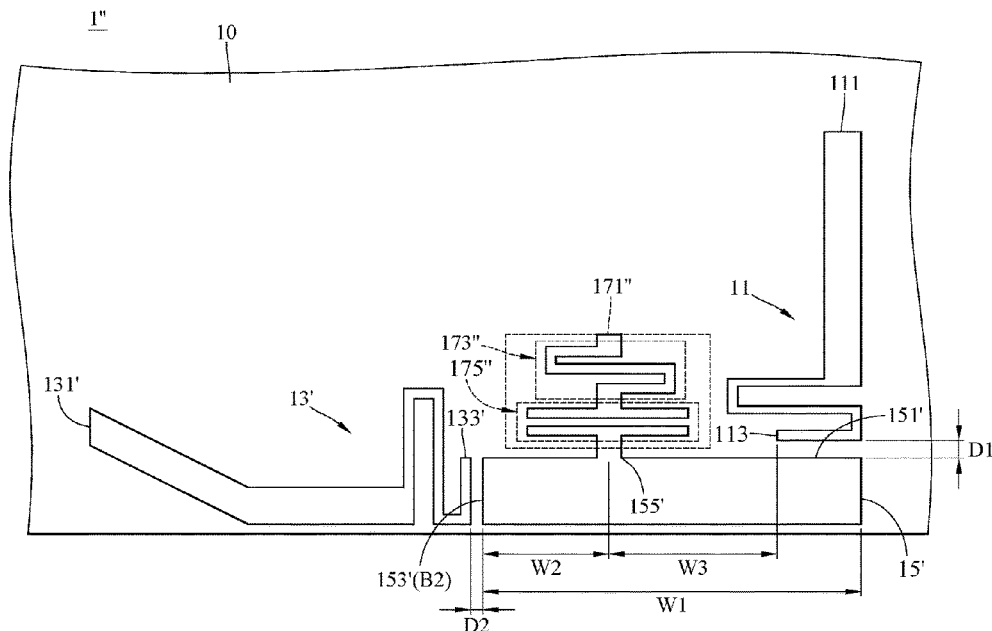
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*Primary Examiner* — Hai V Tran  
*Assistant Examiner* — Michael M Bouizza  
(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Tim Tingkang Xia, Esq.

(57) **ABSTRACT**

A multi-feed antenna comprises a first antenna component, a second antenna component, a metal board and an isolation assembly. The first antenna component comprises a first signal feed-in terminal and a first free end, with the first signal feed-in terminal configured for receiving a first feed-in signal. The second antenna component comprises a second signal feed-in terminal and a second free end, with the second signal feed-in terminal configured for receiving a second feed-in signal. The metal board comprises a first section, a second section and a third section between the first and second sections. The first section and the first free end define a first gap therebetween, and the second section and the second free end define a second gap therebetween. The isolation assembly is electrically connected with the third section, comprises a ground terminal, and is configured for isolating the first and second feed-in signals.

**18 Claims, 4 Drawing Sheets**





(12) **United States Patent**  
**Tsai et al.**

(10) **Patent No.:** **US 10,700,716 B2**  
(45) **Date of Patent:** **Jun. 30, 2020**

- (54) **WIRELESS COMMUNICATION DEVICE**
- (71) Applicant: **HTC CORPORATION**, Taoyuan (TW)
- (72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);  
**Chien-Pin Chiu**, Taoyuan (TW);  
**Hsiao-Wei Wu**, Taoyuan (TW);  
**Yi-Hsiang Kung**, Taoyuan (TW);  
**Shen-Fu Tzeng**, Taoyuan (TW);  
**Li-Yuan Fang**, Taoyuan (TW)
- (73) Assignee: **HTC CORPORATION**, Taoyuan (TW)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/239,710**  
(22) Filed: **Jan. 4, 2019**

(65) **Prior Publication Data**  
US 2019/0140671 A1 May 9, 2019

**Related U.S. Application Data**  
(60) Continuation of application No. 16/139,107, filed on Sep. 24, 2018, now Pat. No. 10,211,858, which is a (Continued)

(51) **Int. Cl.**  
**H04B 1/38** (2015.01)  
**H04B 1/00** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04B 1/006** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/35** (2015.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... H04B 1/0053; H04B 1/0064; H01Q 1/00; H01Q 5/00  
See application file for complete search history.

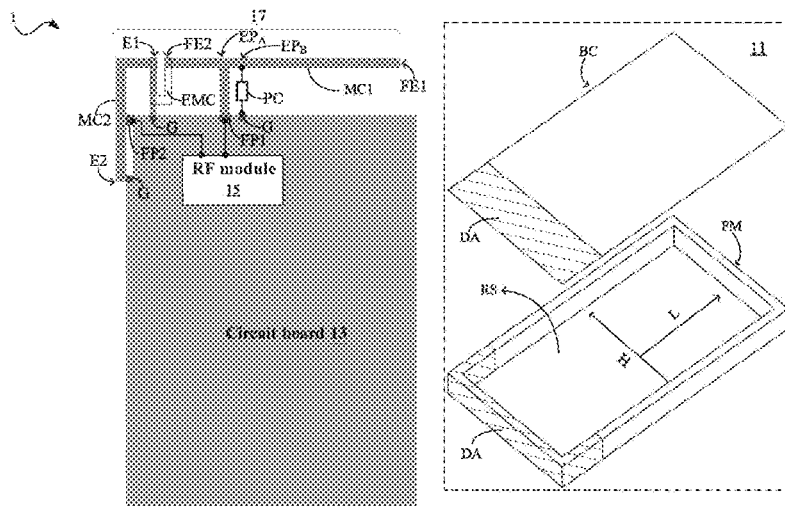
- (56) **References Cited**
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- (Continued)

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English language translation of Chinese office action.

*Primary Examiner* — Tuan Pham  
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**  
A wireless communication device is provided. The wireless communication device includes a housing, a circuit board, a radio frequency module and an antenna. The housing has a frame and a back cover to define a receiving space. The circuit board is disposed in the receiving space, and defines a clearance area from the housing in the receiving space. The circuit board includes a ground terminal, a first feeding point, and a second feeding point. The antenna includes at least one metal conductor coupled to the first feeding point and the second feeding point, respectively, to provide a low frequency resonant path, a first middle frequency resonant path, a second middle frequency resonant path and a high frequency resonant path.

**14 Claims, 22 Drawing Sheets**





(12) **United States Patent**  
**Kim et al.**

(10) **Patent No.:** **US 10,701,194 B2**  
(45) **Date of Patent:** **Jun. 30, 2020**

(54) **ELECTRONIC DEVICE WITH METAL FRAME ANTENNA**

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Gyeonggi-do (KR)

(72) Inventors: **Jaehyung Kim**, Gyeonggi-do (KR);  
**Jinkyu Bang**, Gyeonggi-do (KR); **Jinu Kim**,  
Seoul (KR); **Donghwan Kim**, Gyeonggi-do (KR);  
**Taegyu Kim**, Gyeonggi-do (KR); **Kiyoung Chang**,  
Seoul (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)

(\* ) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/667,415**

(22) Filed: **Oct. 29, 2019**

(65) **Prior Publication Data**  
US 2020/0068054 A1 Feb. 27, 2020

**Related U.S. Application Data**

(63) Continuation of application No. 16/126,534, filed on  
Sep. 10, 2018, which is a continuation of application  
(Continued)

**Foreign Application Priority Data**

Nov. 13, 2015 (KR) ..... 10-2015-0159787

(51) **Int. Cl.**  
**H04B 1/38** (2015.01)  
**H04M 1/02** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04M 1/0218** (2013.01); **H01Q 1/243**  
(2013.01); **H01Q 5/385** (2015.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... H04M 1/0214; H04M 1/0216; H04M  
1/0222; H04M 1/0274; H01Q 5/385;  
H01Q 1/243

See application file for complete search history.

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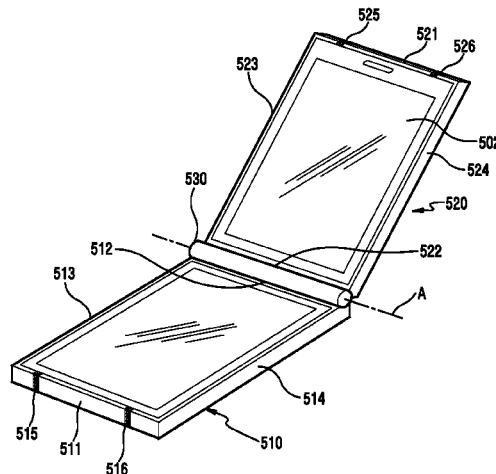
*Primary Examiner* — Tuan Pham

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm,  
P.C.

(57) **ABSTRACT**

An electronic device is provided. The electronic device  
includes a housing and a connection part. The housing  
includes a first housing portion that includes a first side face,  
and a second housing portion that includes a second side  
face. The connection part connects the first housing portion  
and the second housing portion. A first conductive member  
extends along at least a portion of the first side face, a  
first non-conductive member is disposed on the first side  
face, a second conductive member extends along at least a  
portion of the second side face, a second non-conductive  
member is disposed on the second side face, and when the  
second housing portion faces the first housing portion, the  
first

(Continued)



(12) **United States Patent**  
**Hobson et al.**

(10) **Patent No.:** **US 10,707,561 B2**  
(45) **Date of Patent:** **\*Jul. 7, 2020**

(54) **WIRELESS HANDHELD ELECTRONIC DEVICE**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Phillip M. Hobson**, Menlo Park, CA (US); **Stephen P. Zadesky**, Portola Valley, CA (US); **Erik L. Wang**, Redwood City, CA (US); **Tang Yew Tan**, Palo Alto, CA (US); **Richard Hung Minh Dinh**, Saratoga, CA (US); **Adam D. Mittleman**, Portola Valley, CA (US); **Kenneth A. Jenks**, Capitola, CA (US); **Robert J. Hill**, Morgan Hill, CA (US); **Robert W. Schlub**, Palo Alto, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/450,863**

(22) Filed: **Jun. 24, 2019**

(65) **Prior Publication Data**

US 2020/0021012 A1 Jan. 16, 2020

**Related U.S. Application Data**

(63) Continuation of application No. 15/784,814, filed on Oct. 16, 2017, now Pat. No. 10,333,199, which is a (Continued)

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)

(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01);

(Continued)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/273; H01Q 7/00; H01Q 13/10; H01Q 1/38; H01Q 1/46  
See application file for complete search history.

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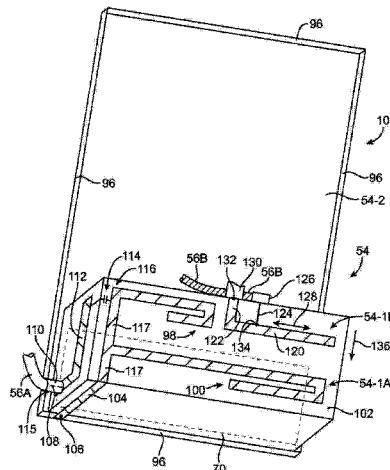
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EP 1988602 11/2008  
*Primary Examiner* — Joseph J Lauture  
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

A handheld electronic device may be provided that contains a conductive housing and other conductive elements. The conductive elements may form an antenna ground plane. One or more antennas for the handheld electronic device may be formed from the ground plane and one or more associated antenna resonating elements. Transceiver circuitry may be connected to the resonating elements by transmission lines such as coaxial cables. Ferrules may be crimped to the coaxial cables. A bracket with extending members may be crimped over the ferrules to ground the coaxial cables to the housing and other conductive elements in the ground plane. The ground plane may contain an antenna slot. A dock connector and flex circuit may overlap the slot in a way that does not affect the resonant frequency of the slot. Electrical components may be isolated from the antenna using isolation elements such as inductors and resistors.

**20 Claims, 38 Drawing Sheets**



(12) **United States Patent**  
**Tseng**

(10) **Patent No.:** **US 10,707,568 B2**  
(45) **Date of Patent:** **Jul. 7, 2020**

- (54) **ANTENNA STRUCTURE**
- (71) Applicant: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)
- (72) Inventor: **Shih-Hsien Tseng**, Hsinchu (TW)
- (73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)
- (\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

- (56) **References Cited**
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- (21) Appl. No.: **16/357,580**
- (22) Filed: **Mar. 19, 2019**
- (65) **Prior Publication Data**  
US 2019/0379110 A1 Dec. 12, 2019

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- Primary Examiner* — Hoang V Nguyen  
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

- (30) **Foreign Application Priority Data**  
Jun. 8, 2018 (TW) ..... 107119820 A

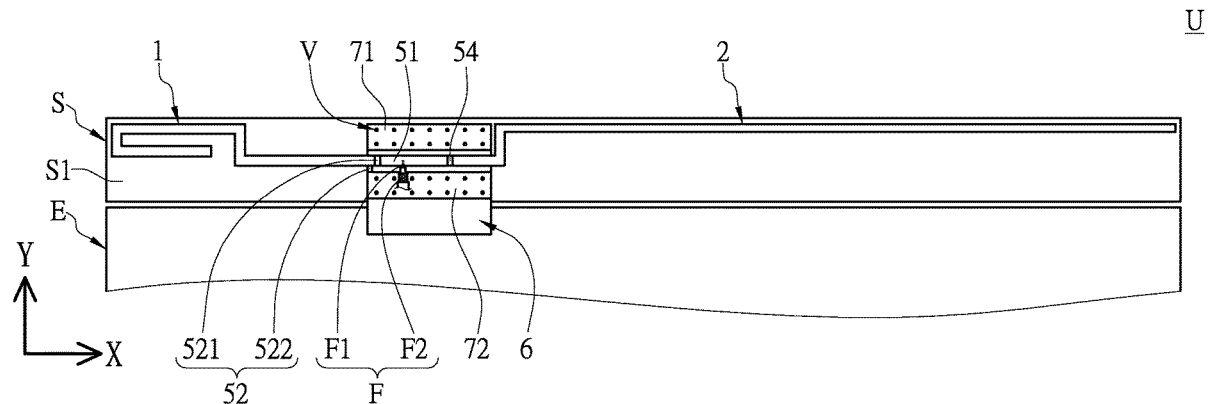
- (51) **Int. Cl.**  
**H01Q 1/50** (2006.01)  
**H01Q 1/36** (2006.01)  
**H01Q 5/335** (2015.01)  
**H01Q 5/328** (2015.01)  
**H01Q 1/48** (2006.01)

- (57) **ABSTRACT**
- An antenna structure includes a substrate, a first radiating element, a second radiating element, a signal transmission assembly, a grounding member, and a feed-in element. The first radiating element is disposed on the substrate. The second radiating element is disposed on the substrate. The signal transmission assembly is disposed on the substrate. The signal transmission assembly includes a signal transmission line, a first impedance matching circuit, and a filter. The signal transmission assembly is coupled between the first radiating element and the second radiating element. The first impedance matching circuit is coupling to the first radiating element and the signal transmission line. The filter is coupling to the second radiating element and the signal transmission line. The feed-in element is coupled between the signal transmission line and the grounding member.

- (52) **U.S. Cl.**  
CPC ..... **H01Q 1/36** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01)

- (58) **Field of Classification Search**  
CPC .. H01Q 1/24; H01Q 1/36; H01Q 1/48; H01Q 1/50; H01Q 5/328; H01Q 5/335  
See application file for complete search history.

**18 Claims, 15 Drawing Sheets**





(12) **United States Patent**  
**Fabrega Sanchez et al.**

(10) **Patent No.:** **US 10,707,582 B2**  
(45) **Date of Patent:** **Jul. 7, 2020**

(54) **WIDE-BAND DIPOLE ANTENNA**  
  
(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)  
  
(72) Inventors: **Jorge Fabrega Sanchez**, San Diego, CA (US); **Mohammad Ali Tassoudji**, San Diego, CA (US)  
  
(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

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(21) Appl. No.: **16/146,742**

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(22) Filed: **Sep. 28, 2018**

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*Primary Examiner* — Graham P Smith  
(74) *Attorney, Agent, or Firm* — Qualcomm Incorporated

(65) **Prior Publication Data**  
US 2020/0106184 A1 Apr. 2, 2020

(57) **ABSTRACT**

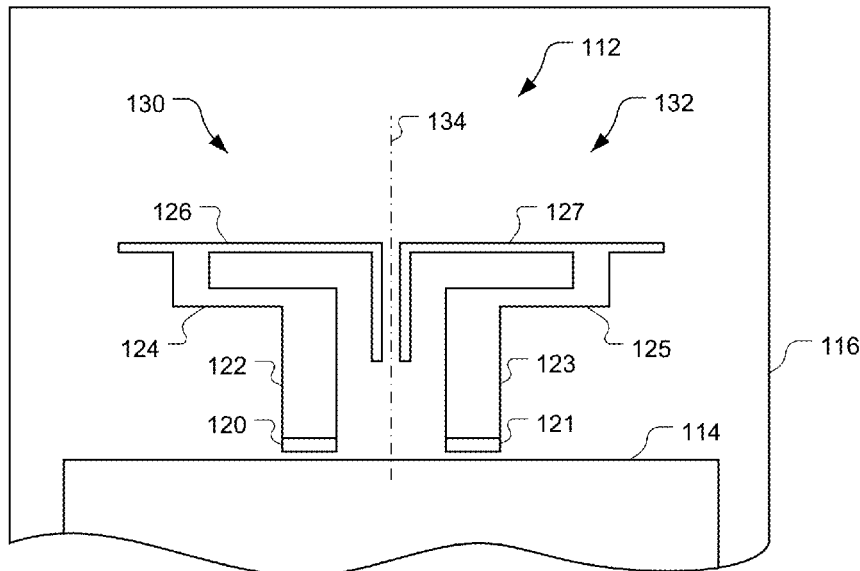
(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 9/26** (2006.01)  
**H01Q 5/364** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 21/06** (2006.01)

A millimeter-wave antenna system includes: a ground plane; and a folded dipole radiator including: a plurality of feeds each extending away from the ground plane from a proximal feed end to a distal end; a plurality of radiating arms each coupled to and extending away from the distal feed end of a respective one of the plurality of feeds; and a plurality of folded conductors each coupled to a respective one of the plurality of radiating arms and each having a distal portion extending toward the ground plane to a distal conductor end; where each of the plurality of feeds and each of the plurality of radiating arms comprises an electrical conductor; and where the folded dipole radiator is discontinuous, without a conductive connection between the plurality of feeds via the plurality of radiating arms.

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/26** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/364** (2015.01); **H01Q 21/062** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 9/26; H01Q 9/42; H01Q 5/364; H01Q 1/243; H01Q 1/38; H01Q 21/062  
See application file for complete search history.

**26 Claims, 7 Drawing Sheets**





US010707583B2

(12) **United States Patent**  
**Kuo et al.**

(10) **Patent No.:** **US 10,707,583 B2**  
(45) **Date of Patent:** **Jul. 7, 2020**

(54) **WIRELESS COMMUNICATION MODULE**

(71) Applicant: **Arcadyan Technology Corporation**,  
Hsinchu (TW)

(72) Inventors: **Shin-Lung Kuo**, Kaohsiung (TW);  
**Shih-Chieh Cheng**, Tainan (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION** (TW)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

(21) Appl. No.: **16/000,691**

(22) Filed: **Jun. 5, 2018**

(65) **Prior Publication Data**  
US 2018/0375212 A1 Dec. 27, 2018

(30) **Foreign Application Priority Data**  
Jun. 23, 2017 (TW) ..... 106120993 A

(51) **Int. Cl.**  
**H01Q 13/18** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/52** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 13/10** (2006.01)

(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/18** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 3/40** (2013.01); **H01Q 9/04** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/52; H01Q 9/0407; H01Q 1/38; H01Q 13/10; H01Q 13/18  
See application file for complete search history.

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*Primary Examiner* — Dameon E Levi

*Assistant Examiner* — Hasan Z Islam

(74) *Attorney, Agent, or Firm* — Innovation Counsel LLP

(57) **ABSTRACT**

A wireless communication module including a substrate, a first antenna, a second antenna and a resonator group is provided. The first antenna and the second antenna are disposed on the substrate. The resonator group is disposed between the first antenna and the second antenna and separated from the first antenna and the second antenna. The resonator group includes a first resonator and a second resonator. The first resonator includes a first resonant cavity, a first extension slot, a first conductive portion and a second conductive portion. The first extension slot extends towards a lateral surface of the substrate from the first resonant cavity. The first conductive portion and the second conductive portion are located within the first resonant cavity and separated from each other. The second resonator includes a second resonant cavity and a second extension slot extending towards the lateral surface from the second resonant cavity.

**4 Claims, 4 Drawing Sheets**

